EXHIBIT B

EXPERT REPORT
Response to Dr. Russell's Rebuttal of March 3, 2023

In re Flint Water Cases
Civil Action No.5:16-cv-10444-JEL-EAS
(consolidated)

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1. INTRODUCTION

At the request of Veolia North America's attorneys, I reviewed the "Rebuttal Report of Dr. Larry L. Russell – Veolia" dated March 3, 2023. Dr. Russell's report does not change my opinions in my February 2023 report, and I am prepared to offer all of those opinions at trial, but I offer the response to Dr. Russell's rebuttal herein.

I reserve the right to supplement and amend my opinions based on and subject to review and analysis of additional discovery information I receive.

This report is respectfully submitted by,

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I have reached the opinions herein, and the opinions in my February 3, 2023 report, based on my review, investigation, and analysis of relevant materials, in light of my knowledge, training, and experience, and I offer the foregoing opinions to a reasonable degree of scientific and engineering certainty.

David C. Crowe

Dr. David C. Crowe
Cincinnati, Ohio
March 14, 2023

2. Sample Removal, Shipping and Storage

The pipe samples, comprising all accessible galvanized steel pipe and any copper pipe with external corrosion product, were cut out, thereby removing all available evidence from the two Flint homes. Some sections could be identified according to photos I took when I performed my visual inspection in 2020. The locations of others could not be determined. The sections had not been labeled (except for a letter), which is one of the simplest fundamental practices of sample-taking. Pipe samples should be sealed on the ends, and the pipe placed in a plastic bag or sleeve, or placed inside a larger plastic tube for protection. These safeguards are basic, and if Dr. Russell has done any tube failure analysis in a professional corrosion engineer context, he should know this. Nonetheless, if he does not, there are references available in the open literature specific to the proper methodology for handling water pipe samples (for example Ref, 1,2).

Contamination by material entering the ends of open pipes is a very real problem when sampling pipes. Shipment together with other pipes, not protected, will allow extraneous material from the outside of other tubes to enter the open ends. For example, while the amount of cross-contaminant lead potentially entering a pipe sample would be small, Dr. Russell's analysis only found lead in exceedingly small percentages in the scale, so this risk is significant. Additionally, in the case of water pipes, they should be sealed to preserve the interior scale wet during shipment, until they are received in the lab for immediate analysis. Instead, Dr. Russell left the pipes open, and then stored them in an uncontrolled environment in his garage for at least a month before inspecting them himself, and for ten months before allowing VNA and its experts to inspect them.

In our December 7, 2022 visual inspection we saw that the scale and deposits inside the pipe samples had dried and flaked, indicating that the scale had changed and deteriorated (3). On p.33 of Ref.4, Dr. Russell writes: "Like ice cores, the remaining pipe scales integrated the past corrosion and water quality conditions into the deposit remaining in the pipe." From this, it seems evident that Dr. Russell knows the importance of scale analysis but neglected to preserve the scale evidence provided by the scale, and did not undertake any but the most cursory scale analysis. Proper scale analysis may have contradicted his position that the scale was removed in 2014-15. Contamination continued during saw cutting of the pipe to view the interior surfaces, as the teeth of the bandsaw blade would have carried cutting particles into the pipes where they would have fallen onto the interior scale layer as the saw blade passed through the pipe.

Dr. Russell charges that I have "provided no actual evidence of contamination" (Ref.4, p.27). To provide conclusive confirmation of contamination from some outside source, I would need to compare a pipe sample that had been properly sealed so it could not be

contaminated – but Dr. Russell made sure that there can be no such comparison. He also did not perform any analysis to show that there was *not* contamination of the sort reasonably expected to occur given the circumstances of shipping and storage.

Dr. Russell claims that "The transport and preservation of the samples were sufficient to preserve the residual flux and the scale that covered it." (4) This is a very low bar for preservation because flux is difficult to remove. He lost any evidence of scale layering; it had dried and was flaking off at our visual inspection of samples. The evidence that would be available from examination of the scale is so damaged that it would be futile to analyze them because the results would be unreliable and not representative of the conditions in the pipes in service. Furthermore, precise compositional analysis would be clouded by the likely contamination that could exceed the ppm concentrations of lead that we would be looking for.

After being cut open, the pipes were evidently stored in damp, uncontrolled conditions in Dr. Russell's garage because the cut surfaces of galvanized steel samples rusted. The internal surfaces of the steel pipes likely corroded further, too.

3. Chain-of-Custody

Chain-of-custody provides a history of the samples not only to ensure they are what they are represented to be, but that the effects of transport can be ascertained. During his deposition, Dr. Russell stated that the shipping container had been opened and inspected by TSA personnel (Ref.5, p.141), and then the container was damaged and had to be replaced (Ref.5, p.353), but the chain of custody tells us nothing about this. Samples were analyzed by a metallurgical engineer, but apparently not left in his possession at all. Dr. Russell stated the samples were stored in his garage (Ref.5, p.142), but then that they were stored about an hour from his house in a storage facility (Ref.5, p.352), neither of which were environmentally controlled. These are significant events in chain-of-custody, and again something that a professional working in corrosion analysis would avoid or at least make note of.

4. Thickness of Copper Pipes

Dr. Russell still provides no evidence that the copper pipes at issue lost any wall thickness compared to new pipe. As I explained in my original report, ASTM Specification B88 provides that Type M ½-inch copper tube has a specified wall thickness of 0.028 inches with a tolerance of 0.003-inch, i.e., per the specification, new copper pipe can be anywhere from 0.025-inches to 0.031-inches thick. Nearly all of Dr. Russell's purported pipe wall measurements are 0.026-inches, within the specification range (6). Indeed, Dr. Russell says that "based on the review of thousands of feet of pipe," "copper pipe is **uniformly**

manufactured to the minimum wall thickness allowed by B88 to save the manufacturer money." (Ref.4, p.28) (emphasis added). Thus Dr. Russell's own wall thickness measurements are entirely consistent with what Dr. Russell says would be expected of new copper pipe. Dr. Russell's acknowledgement that new copper pipe is "uniformly manufactured to the minimum wall thickness allowed in B88" also defeats his unsupported assertion that "it is perfectly logical to use the 0.28-inch [sic] wall thickness as the starting thickness for calculating the loss of wall thickness" (Ref.4, p.39).

As to Dr. Russell's single purported measurement below 0.025-inch (0.019-inches from an unidentified area of a single pipe), there are many possible causes of thin areas in piping aside from corrosion, including manufacturing variations, erosion, tooling damage, and stretching of the outside of bends of a pipe, which are naturally thinner. Dr. Russell still has not identified where he took that measurement, nor has he attempted to rule out other explanations for the result. Dr. Russell has lumped all of the possible causes of thinning together and then attributed them exclusively to corrosion during the Flint Water event. One of the objectives of a metallurgical failure analysis is to determine the causes of thinning. For example, removal of oxides and scale reveal the internal surface of the pipe where etching or pitting from corrosion can be seen, or scratches from tooling to fit-up tube ends to fittings, or fluid erosion (especially at bends), etc. Dr. Russell did not do any of this. Had he done it, likely it would undermine his claim that thinning is all due to corrosion during the 18-month exposure to Flint River water because alternative explanations would be revealed.

Dr. Russell also has not identified any basis to undermine my own wall thickness measurements. Contrary to Dr. Russell's assertions (4), the calipers used during the inspection were adequate quality and accuracy to perform the measurements. The digital calipers, which were purchased from Laboratory Supply Co. (not Home Depot) are accurate to ± 0.0005 inch. For the purpose here, ± 0.001 inch is sufficient. Dr. Russell reports his own measurements at the 0.001-inch level. The calipers were pre-checked with a set of feeler gauges up to 0.035-inch thickness, with full conformance to the gauge, and then confirmed afterward. These calipers have been found to match dimensions obtained with cross-sections measured with an optical microscope when used in a corporate metallurgical lab before I began to use them for field measurements. The calipers served their function. Contrary to Dr. Russell's suggestion, my measurements were not made where there were burrs on the edge of the pipe.

5. Corrosion Rate of Copper Pipe

On p.28 of Ref.4, Dr. Russell states again that the Copper Development Association offers a 50-year warranty on copper pipe, and that this means a corrosion rate of the nominal wall divided by 50. Dr. Russell is incorrect: this is not what the warranty means. It is not a

prediction of the corrosion rate that would be relied upon by a professional in corrosion engineering. (Just like a 100,000-mile power train warranty is not the rate at which your engine will deteriorate by mileage, which will be determined by an individual's use.) Any warranty encompasses a variety of expected life and may only represent a conservative prediction of the life of a majority of circumstances averaged over time and depending on the conditions of service. If most of the corrosion occurs when the copper pipe is new and has not developed a scale/oxide protective layer, then we could have decreasing corrosion rates with time. The warranty is not a basis for calculating corrosion rate in the absence of real measurements. Dr. Russell has no way of knowing when corrosion occurred. It likely did **not** occur during the exposure to the Flint River water as I have already stated.

In the end, Dr. Russell's own wall thickness measurements confirm that Flint River water did not corrode the copper pipes at issue because there was no evidence of any thickness loss. Dr. Russell's measurements are within the allowed range for new copper pipe, and as Dr. Russell himself asserts, "copper pipe is uniformly manufactured to the minimum wall thickness allowed by B88 to save the manufacturer money." (Ref.4, p.28). Dr. Russell's observation defeats his opinion that the copper pipes at issue lost wall thickness during 2014-2015. Dr. Russell's wall thickness measurements are entirely consistent with – and what Dr. Russell says should be expected for - new copper pipe.

6. Galvanized Steel Pipe

There is no evidence of failure of the galvanized steel pipes obtained by Dr. Russell. He claims extensive damage occurred in 2014-2015, but there are no reports of this available, and no repair bills have been presented for houses in Flint associated with the Flint River water event. I have searched extensively on-line for accounts of failure and found none. I consulted with a plumbing professional who works in Flint and he reported that he was not aware of increased plumbing failures during that time period or afterwards.

Dr. Russell contends that the galvanized pipes at failed because the pipes had some pitting. He then simply assumes that the pitting occurred during the Flint River water period, with no proof at all that the pitting did not predate the Flint River water period. Dr. Russell offers no evidence that any pitting occurred in 2014-2015. And regardless of when the pitting occurred, the pipes did not fail. The pipes were used for more than 6 years following 2014-2015, and were still in service when Dr. Russell cut them out. Clearly, the pipes had not failed. If tubing continues to hold water under pressure, it has not failed. The piping in question appears to date from the construction of the house in 1938 making it about 84 years old. After 1960, the owners would likely have used copper to replace lines, but even if the galvanized steel pipes were installed as late as 1960, they're

still very old (62 years). The galvanized steel pipe has simply reached the end of its life, and the condition of the galvanized steel pipe is entirely consistent with normal, old pipe.

Dr. Russell also finds it significant that the galvanized steel pipe sheared off when his plumber tried to remove them. VNA was not present to observe the pipes shearing off, and Dr. Russell did nothing to document the process. In any event, it is not unusual for old, galvanized steel pipe to shear off if enough force is applied, particularly around threads at the end of a pipe, which are naturally thinner due to tapering and thread-cutting. It is also a reckless sampling technique to wrench pipes apart, especially when the sampling party claims that the pipes are damaged in some way.

Pitting occurs in iron or steel water piping underneath tubercles of iron oxide. Stagnant conditions may foster conditions for pitting, and polyphosphate use has been associated with pitting (7), so pitting may have occurred prior to 1997 when orthophosphate treatment started in DWSD water. Use of orthophosphate will discourage pitting, and the presence of iron phosphates may lend protection that endures after the orthophosphate is discontinued.

Dr. Russell states that orthophosphate had not been used by the Detroit system until the 1990s, well into the life of galvanized steel pipe, so it would have pitted very quickly and failed during its years of service before 1997 if we accept his belief that lack of orthophosphate results in sudden, extensive damage.

Dr. Russell does not estimate the rate of corrosion of the galvanized steel pipe, and never exposes the surface under the oxide to see if any damage is present. The wall thickness seen where the pipes were cut longitudinally was thick and uniform. The thickness of the scale suggests that the pipe has been protected by the scale for decades.

On p.37 (Ref.4), Dr. Russell states that "it is extremely likely that there is no interior galvanized coating present in these pipes…" While the zinc coating would be corroded away first to protect the steel underneath, I have seen zinc in samples of scale or on the surface underneath scale of samples of old galvanized pipe. That zinc must have been covered with scale which protected it before it dissolved to protect the steel, or it separated from the steel and was encased in scale. The absence of scale analysis by Dr. Russell meant he could not have seen any, and flaking of the scale due to lengthy, poor storage precludes further analysis. If there was zinc, then its constituent lead (from the zinc/lead alloy used in galvanizing) should be present. Additionally, zinc is adsorbed in iron scale, forming a reservoir for indirect release (8,9).

The presence of lead in galvanizing zinc will affect measurements of lead in scale, so lead there must be differentiated from lead carried there by waters, or in the case of Dr. Russell's samples, on the contamination of the scale (8). Furthermore, we can do this because cadmium is also present in galvanizing zinc and is retained like lead – so the

amount of lead from the galvanizing source can be estimated by proportion to the cadmium measured (8,10).

The results of corrosion tests by Edwards' group at Virginia Tech using nails in Flint waters with and without orthophosphate is informative only as to how new nails would fare in the water during the Flint River water period. This is not useful to the questions at hand in this litigation. The results of Dr. Edwards' test are not relevant to what happened on old scaled pipes which have passivated with tenacious oxide over decades. Contrary to Dr. Russell's reliance on new nails as a predictor of corrosion of scaled pipes, other research by Edwards (7) found that with no inhibitor, in 72-hour stagnation conditions, on average, old pipes had 63% lower iron release than new pipes.

Dr. Russell does not dispute that the Dr. Edwards nail study is not representative because the presence of scale and corrosion deposits on the surface of galvanized steel pipes would have resulted in much lower corrosion rates, as I pointed out in my original report. Instead, he merely asserts that "the steel utilized in nails is high quality" (Ref.4, p.28), without knowing whether said nails actually met the referenced spec, and ignoring the effect of scale in pipes.

Corrosion testing in the EPA test rig for Flint involved careful procedures to preserve surfaces, and then to acclimate them to water conditions in the test loop before making any measurements or conclusions (1). This caution points up the important role of pipe scales in corrosion, and the protection they afford as water conditions fluctuate.

It is telling that Marc Edwards' group never reported any evidence of galvanized steel pipe failures. EPA also never published studies of failures and would have had access to samples, which they surely would have studied if failures were widespread and due to the Flint River water. Russell has disclosed that EPA had no pipe samples from Flint (Ref.5, p.388).

Analysis of galvanized steel pipe samples from the service line at "Residence Zero" in Flint, analyzed by Pieper et al. (10), found scale intact in May 2015. There was no evidence of pitting in this 'worst case' location.

7. References

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2. N. Sadik, “Harvesting Distribution Service Lines and Premise Plumbing for Corrosion Control Studies,” **Opflow**, p.16- 18, October 2021, https://doi.org/10.1002/opfl.1588.
3. Expert Report of David C. Crowe, Feb.3, 2023.
4. Rebuttal Report of Dr. Larry L. Russell, March 3, 2023.
5. Deposition of Dr. Larry L. Russell, Dec. 28-29, 2022.
6. Supplemental Report of Dr. Larry L. Russell, Oct. 18, 2022.
7. L.S. McNeill and M. Edwards, “Phosphate Inhibitors and Red Water in Stagnant Iron Pipes,” **J.Enviro.Eng.**, 126 (12): 1096-1102 (2000).
8. B.N. Clark, S.V. Masters and M.A. Edwards, “Lead Release to Drinking Water from Galvanized Steel Pipe Coatings,” **Env.Eng.Sci.** 30 (8): 713-721 (2015).
9. HDR, “An Analysis of the Correlation between Lead Release from Galvanized Iron Piping and the Contents of Lead in Drinking Water,” Final Report, September 11, 2009.
10. K.J. Pieper, M. Tang and M.A. Edwards, “Flint Water Crisis Caused by Interrupted Corrosion Control: Investigating Ground Zero” Home,” **Environ.Sci.& Tech.**, 51:2007-2014 (2017).